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In re Application of:

TADAYOSHI TOMINAGA et al

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MAIL STOP AFTER FINAL

For: SURFACE TREATING METHODS OF TITANIUM PARTS

DECLARATION UNDER 37 CFR 1.132

We Tadayoshi Tominaga, Naoki Komoto and Teruhisa Ushio do hereby declare as follows:

We are the named inventors of the above-identified patent application.

An error was made in the preparation of the specification of the above-identified patent application in that the proper units were omitted in the disclosure of surface roughness Rz.

Rz is defined in the attached Japanese Industrial Standard JIS B 0601 a copy of which is attached hereto. According to the Standard, a section of standard length is sampled from the mean line on the roughness chart. The distance between the peaks and valleys of the sampled line is measured in the y direction and the average peak is obtained among the five tallest peaks and the

average valley is obtained between the five lowest valleys. The sum of these two values is expressed in micrometers.

Thus, it is known to those of ordinary skill in the art that the proper unit of measurement of the parameter Rz is micrometers.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, or any patent issued thereon.

August 25, 2006
Date

Tadayoshi Tominaga
Tadayoshi Tominaga

August 25, 2006
Date

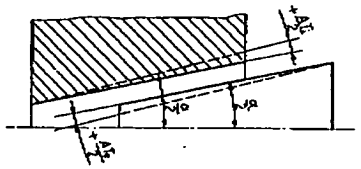
Naoki Komoto
Naoki Komoto

August 25, 2006
Date

Teruhisa Ushio
Teruhisa Ushio

Informative reference 2 Attached Fig. 3.

Position of the cone angle tolerance $AT$ with the same sign symbol for $AT_i$ and $AT_e$ on one side with regard to the basic cone angle $\alpha$

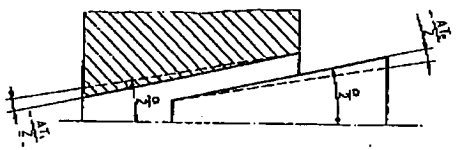


From the indication on drawing:

(a) When internal cone $\alpha^{+AT_i}_{0}$

external cone $\alpha^{+AT_e}_{0}$

it results in contact at the larger or smaller cone diameter or the whole conical surface depending on the actual cone angle.



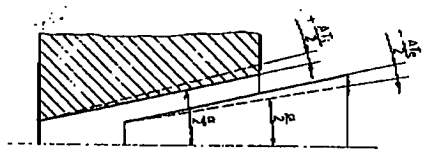
(b) When internal cone $\alpha^{0}_{\Delta T_i}$

external cone $\alpha^{0}_{\Delta T_e}$

it results in contact at the larger or smaller cone diameter or the whole conical surface depending on the actual cone angle.

Informative reference 2 Attached Fig. 4.

Position of the cone angle tolerance $AT$ with opposite sign symbol for $AT_i$ and $AT_e$ on one side with regard to the basic cone angle $\alpha$

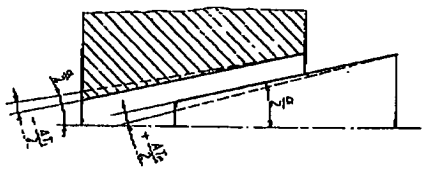


From the indication on drawing:

(a) When internal cone $\alpha^{+AT_i}_{0}$

external cone $\alpha^{0}_{\Delta T_e}$

it results in contact at the smaller cone diameter or at the whole conical surface depending on the actual cone angle.



(b) When internal cone $\alpha^{0}_{\Delta T_i}$

external cone $\alpha^{+AT_e}_{0}$

it results in contact at the larger cone diameter or the whole conical surface depending on the actual cone angle.





# Surface roughness - Definitions and designation

1. Scope This Japanese Industrial Standard specifies the definitions and designation of the arithmetical mean roughness, maximum height, ten-point mean roughness, mean spacing of profile irregularities, mean spacing of local peaks of the profile and profile bearing length ratio, which are the parameters expressing the surface roughness of industrial products.

Remarks: The International standards corresponding to this Standard are shown below:

| | |
|---|---|
| ISO 468-1982 | Surface roughness — Parameters, their values and general rules for specifying requirements |
| ISO 3274-1975 | Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of consecutive profile transformation — Contact profile meters, system M |
| ISO 4287/1-1984 | Surface roughness — Terminology Part 1: Surface and its parameters |
| ISO 4287/2-1984 | Surface roughness — Terminology Part 2: Measurement of surface roughness parameters |
| ISO 4288-1985 | Rules and procedures for the measurement of surface roughness using stylus instruments |

2. Definitions and symbols For the main terms used in this Standard, the following definitions apply.

The symbols for them are given in parentheses following each term.

(1) surface roughness Each arithmetical mean value of arithmetical mean roughness ($R_a$), maximum height ($R_y$), ten-point mean roughness ($R_z$), mean spacing of profile irregularities ($S_m$), mean spacing of local peaks of the profile ($S$) and profile bearing length ratio ($t_p$) which are the parameters expressing the surface roughness at each part sampled randomly from the surface of an object (hereafter referred to as "objective surface").

Remarks 1. Generally in an objective surface, surface roughness on individual positions is not uniform, and usually presents considerably large dispersion. Therefore, in assessing the surface roughness of the objective surface, it is necessary to determine the measuring positions and numbers thereof so that the population mean can be assumed effectively.

2. According to the objects of measurement, an assessed value at one point on the objective surface may represent the surface roughness of the entire surface.

(2) profile curve A contour appears on a cut end, when a surface to be measured has been cut with a plane which is perpendicular to that surface.

Remarks: In this cutting, if the surface has generally the directionality, it shall be cut in perpendicular in that direction.

(3) roughness curve A curve which has been cut off any longer surface waviness component than a prescribed wavelength from the profile curve by means of phase compensation type high-pass filter.

(4) cut-off value of roughness curve ($\lambda_c$) A wavelength corresponding to the frequency which makes the gain of phase compensation type high-pass filter 50 % (hereafter referred to as "cut-off value").

(5) reference length of roughness curve ($l$) A length of a part made by sampling the length of cut-off value from the roughness curve (hereafter referred to as "reference length").

(6) evaluation length of roughness curve ($l_n$) A length including one or more reference length used for evaluation of surface roughness (hereafter referred to as "evaluation length"). The standard value of evaluation length shall be five times the reference length.

(7) waviness of filtered wave A curve made by cutting off the component of surface roughness shorter than a given wavelength from the profile curve by means of phase compensation type low-pass filter [see Fig. 1 (a)].

(8) mean line of roughness curve ($m$) A line made by converting the waviness of filtered wave at the part sampled from the profile curve to the straight line (hereafter referred to as "mean line") [see Fig. 1 (a)].

(9) profile peak An outwardly directed entity of profile surrounded by the roughness curve and the mean line connecting two adjacent points of the intersection made when cutting the roughness curve with the mean line [see Fig. 1 (b)].

Remarks: In the roughness curve, the outwardly directed portion from the mean line at the beginning and the end of the reference length should be considered as a profile peak.

(10) profile valley An inwardly directed portion of space surrounded by the roughness curve and the mean line connecting two adjacent points of intersection made when cutting the roughness curve with the mean line [see Fig. 1 (b)].

Remarks: In the roughness curve, the inwardly directed portion from the mean line at the beginning and end of the reference length should be considered as a valley.

(11) top of profile peak A point of the highest altitude in the profile peak of roughness curve [see Fig. 1 (b)].

(12) bottom of profile valley A point of the lowest altitude in the profile valley of roughness curve [see Fig. 1 (b)].





(13) top of profile peak line Of the reference lengths sampled from the roughness curve, the line parallel to the mean line passing through the highest top of profile peak [see Fig. 1 (b)].

(14) bottom of profile valley line Of the reference lengths sampled from the roughness curve, the line parallel to the mean line passing through the lowest bottom of profile valley [see Fig. 1 (b)].

(15) cutting level A vertical distance between the top of profile peak line and the line parallel to the top of profile peak line intersecting the roughness curve.

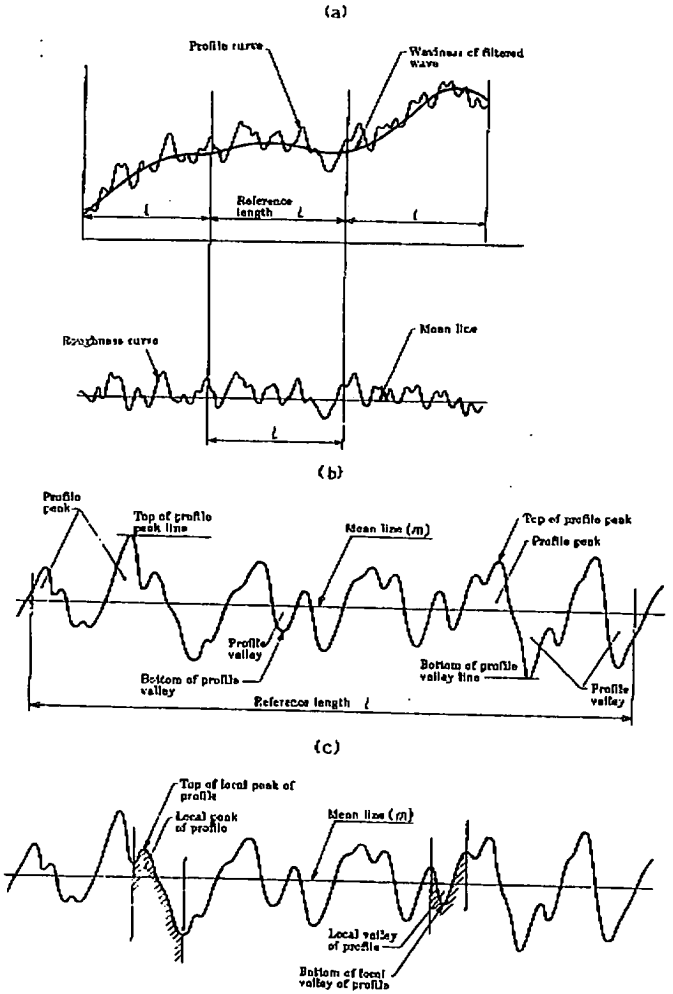
(16) local peak of profile A part of entity between two adjacent minima of the roughness curve [see Fig. 1 (c)].

(17) local valley of profile A part of space between two adjacent maxima of the roughness curve [see Fig. 1 (c)].

(18) top of local peak of profile A point of the highest altitude in the local peak of profile [see Fig. 1 (c)].

(19) bottom of local valley of profile A point of the lowest altitude in the local valley of profile [see Fig. 1 (c)].

Fig. 1. Explanation on profile curve, roughness curve, mean line, reference length, profile peak, profile valley, local peak of profile and local valley of profile








## 3. Definition and designation of arithmetical mean roughness ($R_a$)

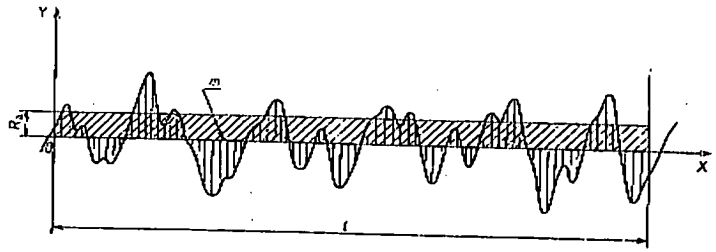
### 3.1 Definition of $R_a$

**3.1.1 Determination of $R_a$** $R_a$ means the value obtained by the following formula and expressed in micrometer (μm) when sampling only the reference length from the roughness curve in the direction of mean line, taking X-axis in the direction of mean line and Y-axis in the direction of longitudinal magnification of this sampled part and the roughness curve is expressed by $y = f(x)$:

$$R_a = \frac{1}{l}\int_0^l |f(x)|dx$$

where, $l$ : reference length

Fig. 2. Determination of $R_a$




**3.1.2 Cut-off values** The cut-off values when obtaining $R_a$ shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

**3.1.3 Standard values of cut-off values** The standard values of the cut-off value and the evaluation length corresponding to the range of $R_a$ when obtaining $R_a$ shall be in accordance with the divisions in Table 1.

Table 1. Standard values of cut-off value and evaluation length in determining $R_a$

| Range of $R_a$ (μm) | | Cut-off value $\lambda_c$ | Evaluation length $l_n$ |
|---|---|---|---|
| Exceeding | Max. | (mm) | (mm) |
| (0.006) | 0.02 | 0.08 | 0.4 |
| 0.02 | 0.1 | 0.25 | 1.25 |
| 0.1 | 2.0 | 0.8 | 4 |
| 2.0 | 10.0 | 2.5 | 12.5 |
| 10.0 | 80.0 | 8 | 40 |

The value within ( ) is given for informative reference.

Remarks: $R_a$ shall be determined by firstly designating the cut-off values. In carrying out the designation or instruction of the surface roughness, as it is inconvenient to designate that on all such occasions, values given in Table 1 should be used generally.

3.2 Expression of $R_a$

3.2.1 Designation of $R_a$ The designation of $R_a$ shall be as follows:

Arithmetical mean roughness _____ μm, Cut-off value _____ mm, Evaluation length _____ mm

or

_____ μm$R_a$, $\lambda_c$ _____ mm, $l_n$ _____ mm

Remarks 1. In the case where the value of $R_a$ obtained by using the standard value of the cut-off value given in Table 1 is in the range shown in Table 1, the designation of the cut-off value may be omitted.

2. In the case where the evaluation length is five times the cut-off value that is the standard value of evaluation length in Table 1 is used, the designation of the evaluation length may be omitted.

3.2.2 Preferred number series of $R_a$ When the surface roughness is designated by $R_a$, the preferred number series of Table 2 should be used generally.





Table 2. Preferred number series of Ra

Unit: μm

| | | | | |
|---|---|---|---|---|
| 0.008 | | | | |
| 0.010 | | | | |
| 0.012 | 0.125 | 1.25 | 12.5 | 125 |
| 0.016 | 0.160 | 1.60 | 16.0 | 160 |
| 0.020 | 0.20 | 2.0 | 20 | 200 |
| 0.025 | 0.25 | 2.5 | 25 | 250 |
| 0.032 | 0.32 | 3.2 | 32 | 320 |
| 0.040 | 0.40 | 4.0 | 40 | 400 |
| 0.050 | 0.50 | 5.0 | 50 | |
| 0.063 | 0.63 | 6.3 | 63 | |
| 0.080 | 0.80 | 8.0 | 80 | |
| 0.100 | 1.00 | 10.0 | 100 | |

Remarks: It is preferable to use the preferred number series of common ratio of 2 shown with thick figures.

3.2.3 Sectional designation of $R_a$ If it is required to designate $R_a$ in a certain section, numerical values corresponding to the upper limit (that of the larger designation value) and lower limit (that of the smaller designation value) shall be stated additionally by selecting from Table 2.

Example 1. In the case where standard values of cut-off values for upper limit and lower limit are equal A sectional designation when the upper limit of 6.3 μm$R_a$ and the lower limit of 3.2 μm$R_a$ shall be designated as (6.3 to 3.2 ) μm$R_a$. In this case, 2.5 mm shall be used for the cut-off value.

Example 2. In the case where standard values of cut-off values for upper limit and lower limit are different A sectional designation when the upper limit of 12.5 μm$R_a$ and the lower limit of 3.2 μm$R_a$ shall be designated as (12.5 to 3.2) μm$R_a$. In this case, it means that the value of $R_a$ measured by a cut-off value of 8 mm is 12.5 μm$R_a$ or under, and that the value of $R_a$ measured by a cut-off value of 2.5 mm is 3.2 μm$R_a$ or over.

Remarks 1. In the case where it is required to equalize the cut-off values corresponding to the upper and lower limits, or in the case where cut-off values other than standard values of Table 1 are to be used, the cut-off values shall be appended. In Example 2., when the cut-off value corresponding to the upper and lower limits is taken as 8 mm, it shall be designated as (12.5 to 3.2) μm$R_a$, $\lambda_c$ 8 mm.

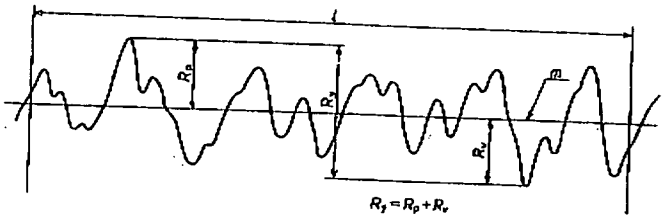
2. $R_z$ of the upper and lower limits mentioned here shall be the arithmetical mean values of $R_z$ at several points sampled randomly from the designated surface, but shall not be the maximum value of individual $R_z$.

## 4. Definition and designation of maximum height ($R_y$)

### 4.1 Definition of $R_y$

4.1.1 Determination of $R_y$ $R_y$ shall be that only the reference length is sampled from the roughness curve in the direction of mean line, the distance between the top of profile peak line and the bottom of profile valley line on this sampled portion is measured in the longitudinal magnification direction of roughness curve and the obtained value is expressed in micrometer (μm) (see Fig. 3).

Fig. 3. Determination of $R_y$




Remarks: In the determination of the maximum height ($R_y$), a length corresponding to the reference length shall be sampled from the part which is free from extraordinary high peak and deep valley considered as flaws.

4.1.2 Reference length In the determination of $R_y$, reference lengths shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25. Unit: mm

4.1.3 Standard values for reference lengths The standard values for reference lengths and evaluation lengths corresponding to the range of $R_y$, when determining $R_y$, should conform to the division of Table 3 generally.





Table 3. Standard values for reference lengths and evaluation lengths in determination of $R_y$

| Range of $R_y$ (μm) | | Reference length $l$ | Evaluation length $l_n$ |
|---|---|---|---|
| Exceeding | Max. | (mm) | (mm) |
| (0.025) | 0.10 | 0.08 | 0.4 |
| 0.10 | 0.50 | 0.25 | 1.25 |
| 0.50 | 10.0 | 0.8 | 4 |
| 10.0 | 50.0 | 2.5 | 12.5 |
| 50.0 | 200.0 | 8 | 40 |

The value within ( ) is given for informative reference.

Remarks: $R_y$ shall be determined upon designation of the reference length at first, however, in indicating and designating the surface roughness, because it is inconvenient to designate that on all such occasions, values given in Table 3 should be used generally.

### 4.2 Expression of $R_y$

4.2.1 Designation of $R_y$ $R_y$ shall be designated as follows:

Maximum height _____ μm, Reference length _____ mm, Evaluation length _____ mm

or

_____ μm$R_y$, $l$ _____ mm, $l_n$ _____ mm

Remarks 1. In the case where the maximum-height value which has been obtained using the standard value of the reference length given in Table 3 lies within the range given in Table 3, the designation of the reference length may be omitted.

2. In the case where the evaluation length uses five times the reference length, namely the standard value of evaluation length shown in Table 3, the designation of evaluation length may be omitted.

4.2.2 Preferred number series of $R_y$ In designating the surface roughness by $R_y$, the preferred number series of Table 4 should be used generally.

Table 4. Preferred number series of $R_y$

Unit: μm

| | | | | | |
|---|---|---|---|---|---|
| | 0.125 | 1.25 | 12.5 | 125 | 1250 |
| | 0.160 | 1.60 | 16.0 | 160 | 1600 |
| | 0.20 | 2.0 | 20 | 200 | |
| 0.025 | 0.25 | 2.5 | 25 | 250 | |
| 0.032 | 0.32 | 3.2 | 32 | 320 | |
| 0.040 | 0.40 | 4.0 | 40 | 400 | |
| 0.050 | 0.50 | 5.0 | 50 | 500 | |
| 0.063 | 0.63 | 6.3 | 63 | 630 | |
| 0.080 | 0.80 | 8.0 | 80 | 800 | |
| 0.100 | 1.00 | 10.0 | 100 | 1000 | |

Remarks: It is recommended to use the number series of common ratio of 2 shown with thick figures.

4.2.3 Sectional designation for $R_y$ If it is required to designate $R_y$ in a certain section, numerical values corresponding to the upper limit (the larger value of the designated value) and the lower limit (the smaller value of the designated value) of that section shall be selected from Table 4 and be stated together.

Example 1. If the standard values for reference lengths of upper and lower limits are equal The sectional designation for the upper limit of 6.3 μm$R_y$ and lower limit of 1.60 μm$R_y$ shall be designated as (6.3 to 1.60) μm$R_y$. In this case, 0.8 mm shall be used for the reference length.

Example 2. If the standard values for reference lengths of upper and lower limits are different The sectional designation for the upper limit of 12.5 μm$R_y$ and lower limit of 1.60 μm$R_y$ shall be designated as (12.5 to 1.60) μm$R_y$. In this case, it means that the value of $R_y$ measured using a reference length of 2.5 mm is 12.5 μm$R_y$ or under, and that the value of $R_y$ measured using a reference length of 0.8 mm is 1.60 μm$R_y$ or over.

Remarks 1. In the case where reference lengths corresponding to the upper and lower limits are required to be equal, or when any reference length other than the standard value of Table 3 is to be used, the reference length shall be stated together. In Example 2., when the reference length corresponding to the upper and lower limits is selected as 2.5 mm, it shall be designated as (12.5 to 1.60) μm$R_y$, *l* 2.5 mm.

2. $R_y$ of the upper and lower limits mentioned here shall be an arithmetical mean value of $R_y$ at several places which have been sampled randomly from the designated surface, but shall not be the maximum value of individual $R_y$.



5.1 Rzの定義.



5. Definition and designation of ten-point mean roughness ($R_z$)

5.1 Definition of $R_z$

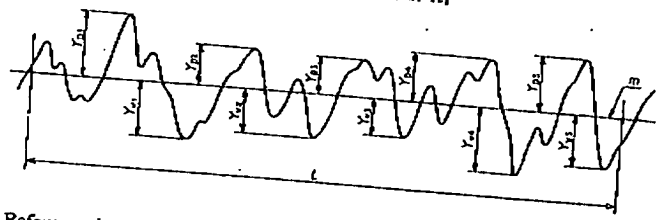
5.1.1 Determination of $R_z$ $R_z$ shall be that only the reference length is sampled from the roughness curve in the direction of its mean line, the sum of the average value of absolute values of the heights of five highest profile peaks ($Y_p$) and the depths of five deepest profile valleys ($Y_v$) measured in the vertical magnification direction from the mean line of this sampled portion and this sum is expressed in micrometer (μm) (see Fig. 4).

$$R_z = \frac{|Y_{p1} + Y_{p2} + Y_{p3} + Y_{p4} + Y_{p5}| + |Y_{v1} + Y_{v2} + Y_{v3} + Y_{v4} + Y_{v5}|}{5}$$

where, $Y_{p1}$, $Y_{p2}$, $Y_{p3}$, $Y_{p4}$, $Y_{p5}$ : altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length *l*

$Y_{v1}$, $Y_{v2}$, $Y_{v3}$, $Y_{v4}$, $Y_{v5}$ : altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length *l*

Fig. 4. Determination of $R_z$




5.1.2 Reference length The reference length, in the determination of $R_z$, shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

5.1.3 Standard values of reference lengths The standard values of the reference lengths and the evaluation lengths corresponding to the range of $R_z$ in the determination of $R_z$, should conform to the division of Table 5 generally.

Table 5. Standard values of reference lengths and evaluation lengths in determining $R_z$

| Range of $R_z$ (μm) | | Reference length $l$ (mm) | Evaluation length $l_n$ (mm) |
|---|---|---|---|
| Exceeding | Max. | | |
| (0.025) | 0.10 | 0.08 | 0.4 |
| 0.10 | 0.50 | 0.25 | 1.25 |
| 0.50 | 10.0 | 0.8 | 4 |
| 10.0 | 50.0 | 2.5 | 12.5 |
| 50.0 | 200.0 | 8 | 40 |

The value within ( ) is given for informative reference.

Remarks: $R_z$ shall be determined on designating the reference length at first. In the case where the indication and designation of the surface roughness are to be carried out, because it is inconvenient to designate this on all such occasions, the values given in Table 5 should be used generally.

5.2 Expression of $R_z$

5.2.1 Designation of $R_z$ The designation of $R_z$ shall be as follows:

Ten-point mean roughness _____ μm, Reference length _____ mm, Evaluation length _____ mm

or

_____ μm$R_z$, $l$ _____ mm, $l_n$ _____ mm

Remarks 1. When the values of $R_z$ obtained by using the standard values of reference length shown in Table 5 are within the range shown in Table 5, the designation of reference length may be omitted.

2. When using the evaluation lengths of five times the reference lengths, namely, the standard values of evaluation lengths shown in Table 5, the designation of evaluation length may be omitted.

5.2.2 Preferred number series of $R_z$ In the designation of the surface roughness by $R_z$, the preferred number series of Table 6 should be used generally.





Table 6. Preferred number series of $R_z$

Unit: μm

| | | | | | |
|---|---|---|---|---|---|
| | 0.125 | 1.25 | 12.5 | 125 | 1250 |
| | 0.160 | 1.60 | 16.0 | 160 | 1600 |
| | 0.20 | 2.0 | 20 | 200 | |
| 0.025 | 0.25 | 2.5 | 25 | 250 | |
| 0.032 | 0.32 | 3.2 | 32 | 320 | |
| 0.040 | 0.40 | 4.0 | 40 | 400 | |
| 0.050 | 0.50 | 5.0 | 50 | 500 | |
| 0.063 | 0.63 | 6.3 | 63 | 630 | |
| 0.080 | 0.80 | 8.0 | 80 | 800 | |
| 0.100 | 1.00 | 10.0 | 100 | 1000 | |

Remarks: It is preferable to use the number series of common ratio of 2 shown in thick figures.

5.2.3 Sectional designation for $R_z$ When it is required to designate $R_z$ in a certain section, numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 6 and be stated together.

Example 1. If the standard values for reference length of upper limit and lower limit are equal The sectional designation for the upper limit 6.3 μm$R_z$ and lower limit 1.60 μm$R_z$ shall be designated as (6.3 to 1.60) μm$R_z$. In this case, 0.8 mm shall be used for the reference length.

Example 2. If the standard values for reference length of upper limit and lower limit are different The sectional designation for the upper limit 12.5 μm$R_z$ and the lower limit 1.60 μm$R_z$ shall be designated as (12.5 to 1.60) μm$R_z$. In this case, it means that the value of $R_z$ measured in the reference length of 2.5 mm is 12.5 μm$R_z$ or under, and that the value of $R_z$ measured in the reference length of 0.8 mm is 1.60 μm$R_z$ or over.

Remarks 1. If it is required to equalize the reference lengths corresponding to the upper and lower limits or if any reference length other than the standard value of Table 5 is used, the reference length shall be stated together. In Example 2., if the reference length corresponding to the upper and lower limits is to be taken as 2.5 mm, it shall be designated as (12.5 to 1.60) μm$R_z$, $l$ 2.5 mm.

2. $R_z$ of the upper and lower limits mentioned here shall be an arithmetical mean value of $R_z$ on several places randomly sampled from the designated surface, and shall not be the maximum value of individual $R_z$.

## 6. Definition and designation of mean spacing of profile irregularities ($S_m$)

### 6.1 Definition of $S_m$

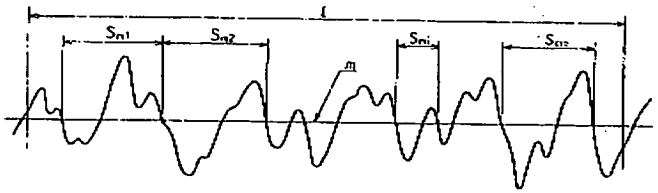
6.1.1 Determination of $S_m$ $S_m$ shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line, and within this sampled portion, the sum of the lengths of mean lines corresponding to one of the profile peaks and one profile valley adjacent to it (hereafter referred to as "spacing of profile irregularities") is obtained and the arithmetical mean value of many spacings of these irregularities is expressed in millimeter (mm) (see Fig. 5).

$$S_m = \frac{1}{n}\sum_{i=1}^{n} S_{mi}$$

where, $S_{mi}$ : spacing of irregularities

$n$ : number of spacings of irregularity lying within the reference length

Fig. 5. Determination of $S_m$




6.1.2 Reference length The reference length, in the determination of $S_m$, shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

6.1.3 Standard values of reference length The standard values of reference lengths and evaluation lengths corresponding to the range of $S_m$ shall, in general, conform to the division of Table 7.





Table 7. Standard values of reference length and evaluation length in determination of $S_m$

| Range of $S_m$ (mm) | | Reference length $l$ | Evaluation length $l_n$ |
|---|---|---|---|
| Exceeding | Max. | (mm) | (mm) |
| 0.013 | 0.04 | 0.08 | 0.4 |
| 0.04 | 0.13 | 0.25 | 1.25 |
| 0.13 | 0.4 | 0.8 | 4 |
| 0.4 | 1.3 | 2.5 | 12.5 |
| 1.3 | 4.0 | 8 | 40 |

Remarks: $S_m$ shall be determined upon designating the reference length. In the indication and designation of surface roughness, because it is inconvenient to designate on every occasion, the standard values of reference length and evaluation length given in Table 7 should be used generally.

### 6.2 Expression of $S_m$

6.2.1 Designation of $S_m$ The designation of $S_m$ shall be as follows:

Mean spacing of profile irregularities _____ mm, Reference length _____ mm, Evaluation length _____ mm

or

_____ mm$S_m$, $l$_____ mm, $l_n$ _____ mm

Remarks 1. If the value of $S_m$ determined by using the standard value of the reference length shown in Table 7 is within the range shown in Table 7, the designation of reference length may be omitted.

2. When using the evaluation length of five times the reference length, namely, the standard value of the evaluation length given in Table 7, the designation of evaluation length may be omitted.

6.2.2 Preferred number series of $S_m$ In the designation of surface roughness by $S_m$, the preferred number series in Table 8 should be used generally.

Table 8. Preferred number series of $S_m$

Unit: mm

| | | | | |
|---|---|---|---|---|
| | 0.0125 | 0.125 | 1.25 | 12.5 |
| | 0.0160 | 0.160 | 1.60 | |
| | 0.020 | 0.20 | 2.0 | |
| 0.002 | 0.025 | 0.25 | 2.5 | |
| 0.003 | 0.032 | 0.32 | 3.2 | |
| 0.004 | 0.040 | 0.40 | 4.0 | |
| 0.005 | 0.050 | 0.50 | 5.0 | |
| 0.006 | 0.063 | 0.63 | 6.3 | |
| 0.008 | 0.080 | 0.80 | 8.0 | |
| 0.010 | 0.100 | 1.00 | 10.0 | |

Remarks: It is preferable to use the number series of common ratio of 2 shown in thick figures.

6.2.3 Sectional designation for $S_m$ When it is required to designate $S_m$ in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 8 and be described together.

Example 1. If the standard values of reference length of upper limit and lower limit are equal The sectional designation for the upper limit of 0.100 mm$S_m$ and the lower limit of 0.050 mm$S_m$ shall be indicated as (0.100 to 0.050) mm$S_m$. In this case, 0.25 mm shall be used for the reference length.

Example 2. If the standard values of reference length of upper limit and lower limit are different The sectional designation for the upper limit of 0.80 mm$S_m$ and the lower limit of 0.20 mm$S_m$ shall be indicated as (0.80 to 0.20) mm$S_m$. In this case, it means that the value of $S_m$ measured in the reference length of 2.5 mm is 0.80 mm$S_m$ or under, and that the value of $S_m$ measured in the reference length of 0.8 mm is 0.20 mm$S_m$ or over.

Remarks 1. If it is required to equalize the reference lengths corresponding to the upper and lower limits or if other reference lengths than the standard values shown in Table 7 are used, the reference length shall be described together. In Example 2., if reference length corresponding to the upper and lower limits is taken as 2.5 mm, it shall be designated as (0.80 to 0.20) mm$S_m$, $l$ 2.5 mm.

2. $S_m$ of the upper and lower limits mentioned here shall be the arithmetical mean value of $S_m$ at several places sampled at random from the designated surface and not be the maximum value of individual $S_m$.





## 7. Definition and designation of mean spacing of tops of local peak of profile ($S$)

### 7.1 Definition of $S$

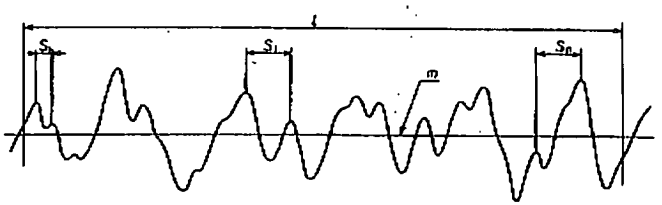
7.1.1 Determination of $S$ $S$ shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line, and within this sampled portion, the length of mean line corresponding to the spacing between two adjacent tops of local peak of profile (hereafter referred to as "spacing of tops of local peak of profile") is obtained and the arithmetical mean value of spacings between these many tops of local peak of the profile is expressed in millimeter (mm) (see Fig. 6).

$$S = \frac{1}{n} \sum_{i=1}^{n} S_i$$

where, $S_i$ : spacing of tops of local peak of profile

$n$ : number of spacings between tops of local peak of profile within the reference length

Fig. 6. Determination of $S$




7.1.2 Reference length The reference length, in the determination of $S$, shall be chosen from the following six kinds in general:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

7.1.3 Standard values of reference length The standard values of reference lengths and evaluation lengths corresponding to the range of $S$ in the determination of $S$ shall conform to the division given in Table 9.

Table 9. Standard values of reference length and evaluation length in determination of $S$

| Range of $S$ (mm) | | Reference length $l$ | Evaluation length $l_n$ |
|---|---|---|---|
| Exceeding | Max. | (mm) | (mm) |
| 0.013 | 0.04 | 0.08 | 0.4 |
| 0.04 | 0.13 | 0.25 | 1.25 |
| 0.13 | 0.4 | 0.8 | 4 |
| 0.4 | 1.3 | 2.5 | 12.5 |
| 1.3 | 4.0 | 8 | 40 |

Remarks: $S$ shall be determined upon designating the reference length. In the indication and designation of surface roughness, because it is inconvenient to designate on every occasion, the standard values of reference length and evaluation length shown in Table 9 should be used generally.

7.2 Expression of $S$

7.2.1 Designation of $S$ The designation of $S$ shall be as follows:

Mean spacing of tops of local peak of profile _____ mm, Reference length _____ mm, Evaluation length _____mm

or

_____ mm$S$, $l$ _____ mm, $l_n$ _____mm

Remarks 1. If the value of $S$ determined by using the standard value of the reference length shown in Table 9, is in the range shown in Table 9, the designation of reference length may be omitted.

2. When using the evaluation length of five times the reference length, namely, the standard value of evaluation length shown in Table 9, the designation of evaluation length may be omitted.

7.2.2 Preferred number series of $S$ In the designation of surface roughness by $S$, the preferred number series in Table 10 should be used generally.





Table 10. Preferred number series of $S$

Unit: mm

| | | | | |
|---|---|---|---|---|
| | 0.0125 | 0.125 | 1.25 | 12.5 |
| | 0.0160 | 0.160 | 1.60 | |
| | 0.020 | 0.20 | 2.0 | |
| 0.002 | 0.025 | 0.25 | 2.5 | |
| 0.003 | 0.032 | 0.32 | 3.2 | |
| 0.004 | 0.040 | 0.40 | 4.0 | |
| 0.005 | 0.050 | 0.50 | 5.0 | |
| 0.006 | 0.063 | 0.63 | 6.3 | |
| 0.008 | 0.080 | 0.80 | 8.0 | |
| 0.010 | 0.100 | 1.00 | 10.0 | |

Remarks: It is preferable to use the number series of common ratio of 2 indicated by thick figures.

7.2.3 Sectional designation for $S$ When it is required to designate $S$ in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 10 and be described together.

Example 1. If the standard values of reference length of upper limit and lower limit are equal The sectional designation for the upper limit of 0.100 mm$S$ and the lower limit of 0.050 mm$S$ shall be indicated as (0.100 to 0.050) mm$S$. In this case, 0.25 mm shall be used for the reference length.

Example 2. If the standard values of reference length of upper limit and lower limit are different The sectional designation for the upper limit of 0.80 mm$S$ and the lower limit of 0.20 mm$S$ shall be indicated as (0.80 to 0.20) mm$S$. In this case, it means that the value of $S$ measured in the reference length of 2.5 mm is 0.80 mm$S$ or under and that the value of $S$ measured in the reference length of 0.8 mm is 0.20 mm$S$ or over.

Remarks 1. If it is required to equalize the reference lengths corresponding to the upper and lower limits or if other reference lengths than the standard values shown in Table 9 are used, the reference length shall be described together. In Example 2., if the reference length corresponding to the upper and lower limits is taken as 2.5 mm, it shall be designated as (0.80 to 0.20) mm$S$, $l$ 2.5 mm.

2. $S$ of the upper and lower limits mentioned here shall be the arithmetical mean value of $S$ at several places sampled at random from the designated surface and not be the maximum value of individual $S$.

## 8. Definition and designation of profile bearing length ratio ($t_p$)

### 8.1 Definition of $t_p$

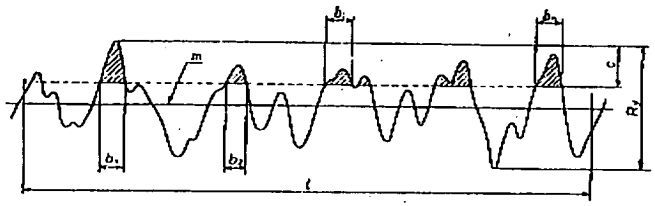
8.1.1 Determination of $t_p$ $t_p$ shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line and the ratio of the sum of cut lengths obtained at the time of cutting this sampled portion of roughness curve at the cutting levels parallel to the top of profile peak line (profile bearing length, $\eta_p$) to the reference length is expressed in percentage (see Fig. 7).

$$t_p = \frac{\eta_p}{l} \times 100$$

where, $\eta_p$ : $b_1 + b_2 + \cdots + b_n$

$l$ : reference length

Fig. 7. Determination of $t_p$




8.1.2 Reference length The reference length, in the determination of $t_p$, shall be selected from the following six kinds in general:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

8.1.3 Cutting level The cutting level at the time of determining $t_p$ shall be in accordance with any one of the following two methods:

(1) Express with the numerical value in micrometer (μm).

(2) Express its ratio to $R_y$ with percentage (%). The preferred number series to be used in this case is shown below:

5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 90

Remarks: When expressing $c$ with the percentage (%) in accordance with (2), it is necessary to obtain $R_y$ in the first place from the roughness curve in the reference length.





### 8.2 Expression of $t_p$

8.2.1 Designation of $t_p$ The designation of $t_p$ shall be as follows:

Profile bearing length ratio ____ %, level ____ μm, length ____ mm, length ____ mm

or

____ % $t_p$, $c$ ____ μm, $l$ ____ mm, $l_n$ ____ mm

Or

Profile bearing length ratio ____%, level ____ %, length ____ mm, length ____ mm

or

____% $t_p$, $c$ ____ %, $l$ ____ mm, $l_n$____mm

Remarks: To the briefing form for designating the reference length and evaluation length, the case of $R_y$ applies (see Remarks 1. and 2. in 4.2.1).

8.2.2 Preferred number series of $t_p$ When designating the surface roughness by $t_p$, the preferred number series in Table 11 shall be used in general.

Table 11. Preferred number series of $t_p$

| $t_p$ (%) | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|

8.2.3 Sectional designation for $t_p$ When it is required to designate $t_p$ in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) shall be selected from Table 11 and be described together.

Remarks: For the standard values of reference lengths for the upper limit and lower limit, the values specified in Table 3 at the time of determining $R_y$ shall be used.

Example 1. If the reference length is equal to the standard value In the case of (6.3 to 1.60) μm$R_y$, 0.8 mm shall be used as the reference length. The sectional designation for the upper limit of $t_p$ of 60 % and the lower limit thereof of 40 % shall be (60 to 40) %$t_p$, $c$40%.

Example 2. If the reference length is unequal to the standard length The upper limit and lower limit of $t_p$ shall be described together and the following reference length shall be written additionally:

(60 to 40) %$t_p$, $c$40 %, $l$ 2.5 mm

Remarks: $t_p$ of the upper limit and lower limit mentioned here shall be the arithmetical mean value of $t_p$ at several places sampled at random from the designated surface and not be the maximum value of individual $t_p$.

Annex Definition and designation of center line average roughness

1. Scope This Annex specifies the definition and designation of the center line average roughness ($R_{a75}$).

Informative reference: The contents of this Annex which are not in conformance with the International standards will be abolished at an appropriate time.

2. Definitions and symbols For the main terms used in this Annex, the following definitions apply:

The symbols for them are shown in ( ), next to the respective terms.

(1) roughness curve for determining $R_{a75}$ (75%) Curve made by extracting the components of surface roughness shorter than a given wavelength on a profile curve by using the high-pass filter of the decay factor of −12 dB/oct [hereafter referred to as "roughness curve (75 %)"].

(2) cut-off value (75 %) of roughness curve (75 %) ($\lambda_{c75}$) The wavelength corresponding to the frequency with which the gain of high-pass filter becomes 75 % [hereafter referred to as "cut-off value (75 %)].

(3) mean line of roughness curve (75 %) The straight line or the curve having the geometrical shape of the surface to be measured at the sampled portion of roughness curve (75 %) and the line set so as to make the sum of squares of deviation up to the roughness curve (75 %) minimum.

(4) center line of roughness curve (75 %) The straight line or the curve on the both sides of which the area surrounded by the straight line or the curve parallel to the mean line of roughness curve (75 %) and the roughness curve (75 %) become equal (hereafter referred to as "center line").

3. Definition and designation of center line average roughness ($R_{a75}$)

3.1 Definition of $R_{a75}$

3.1.1 Determination of $R_{a75}$ $R_{a75}$ is the value obtained by the following formula and expressed in micrometer (μm) under the condition that the portion of measuring length ($L$) is sampled from the roughness curve (75 %) in the direction of its center line, the center line of the sampled portion is considered as X-axis and the direction of the longitudinal axis as Y-axis, and the roughness curve (75 %) is represented by $y = f(x)$:

$$R_{a75} = \frac{1}{L}\int_0^L |f(x)|dx$$

where, $L$ : measuring length





3.1.2 $\lambda_{c75}$ $\lambda_{c75}$ shall be the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

3.1.3 Standard value of $\lambda_{c75}$ The standard value of $\lambda_{c75}$ shall, in general, be in accordance with the division shown in Annex Table 1.

Annex Table 1. Standard value of $\lambda_{c75}$ in determining of $R_{a75}$

| Range of $R_{a75}$ (μm) | | Cut-off value (75 %) $\lambda_{c75}$ (mm) |
|---|---|---|
| Exceeding | Max. | |
| — | 12.5 | 0.8 |
| 12.5 | 100 | 2.5 |

Remarks: $R_{a75}$ shall be determined upon designating $\lambda_{c75}$ first. When designating or instructing the surface roughness, the values given in Annex Table 1 are used in general, because it is inconvenient to designate them at every time.

3.1.4 Measuring length The measuring length shall be the value not shorter than three times $\lambda_{c75}$.

3.2 Expression of $R_{a75}$

3.2.1 Designation of $R_{a75}$ The designation of $R_{a75}$ shall be as follows:

Center line average roughness (75 %) _____ μm, Cut-off value (75 %) _____ mm, Measuring length _____ mm

or

_____ μm$R_{a75}$, $\lambda_{c75}$ _____ mm, $L$ _____ mm

Remarks 1. If the value of $R_{a75}$ obtained by using the standard value of $\lambda_{c75}$ shown in Annex Table 1 lies within the range of Annex Table 1, the designation of $\lambda_{c75}$ may be omitted.

2. If the measuring length is three times $\lambda_{c75}$ or longer, the designation of measuring length may be omitted.

3.2.2 Preferred number series of $R_{a75}$ When designating the surface roughness by $R_{a75}$, the preferred number series in Annex Table 2 should be used generally.

Annex Table 2. Preferred number series of $R_{z75}$

Unit: μm

| | | |
|---|---|---|
| 0.013 | 0.4 | 12.5 |
| 0.025 | 0.8 | 25 |
| 0.05 | 1.6 | 50 |
| 0.1 | 3.2 | 100 |
| 0.2 | 6.3 | |

3.2.3 Sectional designation for $R_{z75}$ When it is required to designate $R_{z75}$ in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) shall be selected from Annex Table 2 and be described together.

Example 1. If the standard values of $\lambda_{c75}$ at the upper limit and the lower limit are equal The sectional designation for the upper limit of 6.3 μm$R_{z75}$ and the lower limit of 1.6 μm$R_{z75}$ shall be (6.3 to 1.6) μm$R_{z75}$. In this case, the cut-off value (75 %) of 0.8 mm shall be used.

Example 2. If the standard values of $\lambda_{c75}$ at the upper limit and the lower limit are different The sectional designation for the upper limit of 25 μm$R_{z75}$ and the lower limit of 6.3 μm$R_{z75}$ shall be (25 to 6.3) μm$R_{z75}$. In this case, it means that the value of $R_{z75}$ measured with $\lambda_{c75}$ 2.5 mm is not more than 25 μm$R_{z75}$ and the value of $R_{z75}$ measured with $\lambda_{c75}$ 0.8 mm is not less than 6.3 μm$R_{z75}$.

Remarks 1 If it is required to equalize both $\lambda_{c75}$ corresponding to the upper limit and the lower limit or if the values of $\lambda_{c75}$ other than the standard values in Annex Table 1 are used, $\lambda_{c75}$ shall be written together. In Example 2., if $\lambda_{c75}$ corresponding to the upper limit and the lower limit is 2.5 mm, the designation shall be (25 to 6.3) μm$R_{z75}$, $\lambda_{c75}$ 2.5 mm.

2. $R_{z75}$ of the upper limit and lower limit mentioned here shall be the arithmetical mean value of several places sampled at random from the designated surface and not be the maximum value of individual $R_{z75}$.





# General tolerances—Part 1: Tolerances for linear and angular dimensions without individual tolerance indications

**Foreward as the Japanese Industrial Standard**

This Standard is the Japanese Industrial Standard drawn up without changing the technical contents and the form of copy of standard, translating the ISO 2768-1 (General tolerances—Part 1: Tolerances for linear and angular dimensions without individual tolerance indications) published on 1989 as the first edition.

Furthermore, "Informative References" underlined (dotted lines) in this Standard are the matters not included in the original International Standard.

## Introduction

All features on component parts always have a size and a geometrical shape. For the deviation of size and for the deviations of the geometrical characteristics (form, orientation and location) the function of the part requires limitations which, when exceeded, impair this function.

The tolerancing on the drawing should be complete to ensure that the elements of size and geometry of all features are controlled, i.e. nothing shall be implied or left to judgement in the workshop or in the inspection department.

The use of general tolerances for size and geometry simplifies the task of ensuring that this prerequisite is met.

## 1. Scope

This Standard is intended to simplify drawing indications, and it specifies general tolerances for linear and angular dimensions without individual indications in four tolerance classes.

Remarks 1. The concepts behind the general tolerancing of linear and angular dimensions are described in Annex A.

This Standard applies to the dimensions of parts which have been produced by metal removal or parts which have been formed from sheet metal.

2. These tolerances may be suitable for use with materials other than metal.

3. Similar standards exist or are planned. For example, see JIS B 0403 for castings.

Informative reference: JIS B 0403-1987 is the International Conforming Standard of ISO 8062: 1984 (Castings-System of dimensional tolerances).

This Standard only applies to the following dimensions without individual tolerance indications: